mesa can be formed by adhering material to the substrate in a localized area to define the acoustic cavity. In the latter embodiment, the material forming the mesa may be the same as or a different material than the material forming the substrate. The substrate may be formed of metal, plastic, glass or ceramics, etc., capable of supporting a resonant acoustic wave. Moreover, the switch can use a wall of a housing or device enclosure as the substrate so that at least a portion of the switch, i.e. the acoustic cavity is an integral part of the housing wall. As such, no holes have to be formed in the housing or enclosure to accommodate the switch, eliminating sealing problems and providing a switch which is extremely rugged.

[0010] In a preferred embodiment, a shear wave transducer is mounted on the acoustic cavity so as to generate a shear wave in the plane of the substrate and parallel to the touch surface. The shear wave, however, has a higher order mode than the zeroth order mode so that the wave can be substantially confined to or trapped in the acoustic cavity. It should be appreciated, however, that acoustic waves, capable of being substantially trapped in an acoustic cavity, other than a shear wave can be used in accordance with the present invention as well.

[0011] The acoustic wave switch of the present invention is low-cost, rugged, explosion proof, operates with simple, low-powered electronics and continues to function in the presence of ionizing environments, liquids and other contaminants. These and other objects, advantages and novel features of the present invention, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0012] **FIG. 1** is a top view of a panel having a number of acoustic wave switches formed therein in accordance with the present invention;

[0013] **FIG. 2** is a perspective view of the back of the panel of **FIG. 1** illustrating the substrate, mesas and associated transducers forming the acoustic wave switches;

[0014] **FIG. 3** is a side cross-sectional view of an acoustic wave switch of **FIGS. 1 and 2** illustrating the acoustic cavity of the present invention;

[0015] **FIG. 4** is a top view of the acoustic wave switch of **FIG. 3** illustrating the displacement of the transducer and the direction of propagation of a shear wave in the plane of the substrate;

[0016] **FIG. 5** is a side cross-sectional view of the acoustic wave switch illustrating the displacement of a first order mode shear wave in the y-x plane;

[0017] **FIG. 6** is a side cross-sectional view of the acoustic wave switch illustrating the displacement of a third order mode shear wave in the y-x plane;

[0018] **FIG. 7** is a cross-sectional view of the acoustic wave switch illustrating the displacement of a shear wave having m=0 in the y-z plane;

[0019] **FIG. 8** is a cross-sectional view of the acoustic wave switch illustrating the displacement of a shear wave having m=2 in the y-z plane;

[0020] **FIG. 9** is a schematic diagram of a touch detection circuit for the acoustic wave switch of FIGS. **1-3**;

[0021] **FIG. 10** is a cross-sectional view of an acoustic wave switch in accordance with the present invention having a depressed area indicating a touch region;

[0022] **FIG. 11** is a cross-sectional view of an acoustic wave switch in accordance with the present invention having a raised area indicating a touch region;

[0023] **FIG. 12** is an acoustic wave switch having a mesa formed on the touch surface;

[0024] **FIG. 13** is a cross-sectional view of an acoustic wave switch with an acoustic wave absorbing switch actuator to provide feedback to a user that the switch has been actuated;

[0025] **FIG. 14** is an illustration of the acoustic wave switch of **FIG. 3** with the switch actuator in the actuated position;

[0026] **FIG. 15** is an illustration of a number of acoustic wave switches of the type shown in **FIG. 11** with an overlay;

[0027] **FIG. 16** is a graph illustrating the change in the transducer's impedance at peak resonance, in the absence of a touch and in the presence of a touch;

[0028] **FIG. 17** is a perspective view of the acoustic wave switch with a circular mesa;

[0029] **FIG. 18** is a cross-sectional view of the acoustic wave switch of **FIG. 17** with the transducer mounted on a surface of the substrate opposite the circular mesa;

[0030] **FIG. 19** is a perspective view of the acoustic wave switch with a circular mesa defined by a moat in the substrate;

[0031] **FIG. 20** is a perspective view of the acoustic wave switch with a dome shaped mesa surrounded by a moat in the substrate; and

[0032] **FIG. 21** is a cross-sectional view of the acoustic wave switch of **FIG. 20** illustrating the transducer on a surface of the substrate opposite the dome.

DETAILED DESCRIPTION OF THE INVENTION

[0033] A touch panel as shown in **FIGS. 1 and 2** has a number of acoustic wave switches in accordance with the present invention formed in the substrate **14** of the touch panel. Each acoustic wave switch **12** has respective indicia **16** formed on a top surface **18** of the panel. The indicia **16** identifies the position of a switch **12** and a switch actuation touch surface which are centrally located in the indicia **16**. The indicia **16** can be formed in a number of different ways as described in detail below.

[0034] As shown in **FIG. 2** and in more detail in **FIG. 3**, each acoustic wave switch **12** has an associated acoustic wave cavity **20** that extends through the thickness b_s of the substrate **14**. The acoustic wave cavity **20** is formed in the substrate **14** such that the mass per unit surface area of the acoustic wave cavity **20** is greater than the mass per unit surface area of the substrate adjacent the cavity. In one embodiment, the mass per unit area of the substrate in the switch region is increased to form the acoustic wave cavity